

**DEVELOPING EMISSION BASELINES
FOR MARKET-BASED MECHANISMS:
A CASE STUDY APPROACH**

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EXECUTIVE SUMMARY

Chapter 1. Introduction

Concern about increasing atmospheric concentrations of carbon dioxide and other greenhouse gases, and the potential impact of these increases on the earth's climate, has grown significantly over the past decade. This concern has led to a series of international meetings and agreements seeking to stabilize atmospheric greenhouse gas concentrations. In 1992, at Rio De Janeiro, the Framework Convention on Climate Change (UNFCCC) was signed by more than 160 countries, including the United States. There was widespread agreement among the signatories on the potential negative effects of climate change under a business-as-usual future. Under the convention, the developed countries (referred to as Annex I countries) were assigned primary responsibility for addressing the climate change issue. However, between 1992 and 1997, Parties to the Convention strongly disagreed over what policy instruments should be used to curb global climate change, and what, if any, targets and timetables should be set for achieving emission reductions.

A break in the negotiations occurred in late 1997. At the Third Conference of Parties¹ held in Kyoto, Japan in December 1997, a series of firm emission reduction targets were agreed to by the Parties. The industrialized countries agreed to reduce their greenhouse gas emissions by an average of 5.2 percent from 1990 levels by 2008-2012. The U.S. agreed to limit its emissions to seven percent below 1990 levels. Since then negotiations on implementing these reductions have stalled and the Protocol has not been ratified. However, major progress in allowing the use of market mechanisms to achieve emission reduction goals occurred at Kyoto. Emissions trading and a new concept where entities can acquire credits for emission reduction activities were among the market-based mechanisms under consideration. This report is concerned exclusively with the latter.

One example of a market mechanism is the Clean Development Mechanism (CDM). A CDM activity is defined in Article 12 of the Kyoto Protocol as a project between a developed country and a developing country that provides the developing country with project financing and technology, while assisting the developed country in meeting its emission reduction commitments. Under the CDM, projects yield emission reductions credits. The share of these credits that is accrued by entities in industrialized countries may be applied towards their own emission reduction goals. Credits are verified and authenticated units of greenhouse gas reductions from abatement or sequestration projects. They are issued pursuant to the review and certification of each project, by an operational organization (CDM Board) to be defined by the Conference of Parties. To obtain credits in a market mechanism environment, a project will likely need to meet the following criteria: 1) voluntary participation; 2) real, measurable, and long-term mitigation of climate change; 3) benefits in addition to what would have occurred in the absence of the project activity (additionality); and 4) projects

¹The Conference of the Parties (COP) is the supreme body of the United Nations Framework Convention on Climate Change established in 1992. The body meets annually and its primary responsibility is to oversee the implementation of the Convention. The Sixth Conference of Parties (COP6) is scheduled for November, 2000.

must contribute to the sustainable development goals of the host country. Sustainable development benefits are not limited to, but should include the following: income benefits, employment benefits, benefits to the local environment, quality of technology transferred, and contributions to the local capacity to sustain and build on the projects. As these factors vary among countries, it will be the responsibility of the individual host country government to determine whether projects satisfy national sustainable development objectives.

It is important to recognize that the market mechanisms are *not* designed to reduce global greenhouse gas emissions beyond emission reduction targets such as those specified in the Kyoto Protocol. Rather, the purpose of market mechanisms is to increase flexibility and reduce the *costs* associated with meeting emission reduction targets. The CDM for example, provides for a one-to-one trade between developed and developing countries. Thus, at least in the ideal, market-based projects will yield no net change in global emissions. In short, it is the emission reduction targets specified in some future international emission reduction agreements, and not the market mechanisms, that will act as the driving force for reducing global greenhouse gas emissions.

While from the perspective of Annex I countries the purpose of the market mechanisms is to reduce the costs associated with reducing emissions, they may be perceived differently by the developing countries (non-Annex 1 countries). The latter may view the market mechanisms as a means of fostering their sustainable development goals. Under the market mechanisms, developing countries will have access to favorable financing for certain types of projects; market-based projects will be required to not only reduce emissions, but also meet the sustainable development goals of the host countries. Although various formal criteria have been suggested for assessing a project relative to the goal of sustainable development, in the final analysis each host country will judge for itself whether or not proposed projects meet its sustainable development goals.

If they can be implemented as originally envisioned, the market mechanism will provide a “win-win” opportunity: it will enable developing countries to further their sustainable development goals while at the same time reducing the developed countries’ emission reduction costs. But while the market mechanisms in general may, at least in theory, wed these two different goals in a mutually beneficial union, in practice tension may arise between the two objectives. In particular, the developed countries have voiced their concern that they may become a kind of “dumping ground” for high-risk, uneconomic experimental technologies that developed countries are unwilling to develop domestically. Yet it is precisely advanced, high-risk, marginally economic technologies that most clearly qualify as additional under market mechanisms. Projects utilizing conventional technologies, which may better meet the host countries’ goals, may also in many cases fail to meet the test for additionality. This underlying tension, and more importantly how it is addressed, may to a large extent decide the success or failure of the market mechanisms. Success will require the striking of a delicate balance between developed and developing country goals.

This report represents a step towards the development of protocols for the estimation of greenhouse gas emission reductions resulting from potential market mechanism projects undertaken in the power sector. It deals specifically with the difficult and complex problem of developing emission baselines

for carbon offset projects. Although exchanging credits for emission reduction activities and technologies is a relatively new concept, much has already been written about it. The literature has identified and developed a number of approaches to emission baseline estimation under the market mechanism concept, and the pros and cons of each approach have been assessed and reviewed at some length (see bibliography). However, the literature has to a large extent considered baseline estimation only in the abstract. Different estimation approaches have been compared and contrasted, but, to date, few attempts have been made to *apply* these approaches.

The primary goal of this report is to help advance the discussion of baseline estimation procedures by *applying* alternative estimation approaches to three hypothetical project case studies. Thus, following an analysis of the three major baseline methodologies under consideration for the market mechanisms, we apply two of these methodologies to hypothetical emission reduction projects.

One of these projects, designed to improve the efficiency of coal-fired power plants in India, is based on an actual ongoing project that is being sponsored by the U.S. Agency for International Development, along with the U.S. Department of Energy's National Energy Technology Laboratory (NETL), the Tennessee Valley Authority, the Electric Power Research Institute, and India's National Thermal Power Corporation (NTPC). In this report, an emissions baseline for the project is developed using the project-specific approach. The other two projects – an Integrated Gasification-Combined Cycle (IGCC) project in China and a fuel cell project in Argentina – are of a more hypothetical nature, although similar projects are being considered by these countries and others. The authors utilize the modified technology matrix approach to evaluate both of these projects.

Key Definitions

Project-specific Approach: involves the tailoring of a separate baseline estimation methodology to each individual project, based on a detailed analysis of the project's defining characteristics.

Modified Technology Matrix Approach: a set of technologies is pre-qualified as additional based on a consideration of their economics and current market penetration; baseline emission rates are stipulated.

Benchmark Approach: a set of stipulated baseline emission rates are provided for different countries, sectors, or sub-sectors.

Our case studies involve two distinct steps. First, for each project, we adopt the viewpoint of the project developers. From this subjective viewpoint, we attempt to develop as persuasive an argument as possible in support of the additionality (the notion that a project would only happen because of market mechanism incentives) of the three projects. In addition, we seek to be as rigorous as possible in our attempts to develop accurate, reliable project baselines and benchmarks.

Then, following the completion of the three project analysis, we adopt an objective viewpoint, and submit the analysis to a critique. By applying the baseline development approaches in as rigorous a manner as possible, and then subjecting the results of these analysis to an objective critique, our goal is to identify the strengths and weaknesses of each approach under a “best-case” scenario. More specifically, our objective is to identify potential error sources for each approach, and to provide at

least a rough qualitative characterization of these error sources as to their magnitude and potential for biasing global-level emission reduction estimates. Only by approaching baseline development with some rigor can we ensure that the error assessment excludes errors resulting from a mere lack of diligence, and focuses on those more formidable errors that may be inherent to the nature of the estimation approaches, and to the nature of the baseline development problem itself.

We apply two different baseline development approaches – the project-specific approach and the modified technology matrix approach – because each approach has its applications, and significant benefits may be gained by combining both approaches in a set of flexible protocols, rather than choosing one over the other for all circumstances. Owing to the complexity and cost associated with the project-specific approach, the modified technology matrix approach is more applicable to the China and Argentina projects. The India project, on the other hand, can satisfy the additionality requirement only under the project specific approach because this project does not easily lend itself to standardization.

Chapter 2. Approaches for Quantifying the Emission Baseline

To evaluate the options for developing emission baselines under a market mechanism environment, we first examine the characteristics and criteria for developing greenhouse gas emission baselines under the UNFCCC. Emission baselines represent the standard from which a measure of valid emission reductions or carbon sequestration is established. The baseline can either be derived from a forecast of emissions of the actual activity to be replaced, or on a specific set of emission data collected from relevant sectors within the economy. Once the baseline has been constructed, the emissions associated with the proposed market-based project are calculated and subtracted from the baseline to determine the actual emission reductions of the project.

The development of emission baselines that are accurate and incur low transaction costs is crucial to enhance market mechanism participation and, at the same time, ensure that the credits developed have a positive environmental impact. In the literature on baseline development, four general requirements have been proposed to promote these objectives. The first and most important requirement refers to the issue of additionality; that is, the question whether the activity would occur in the absence of market mechanism incentives. Some amount of emission reduction activities are bound to happen without the implementation of an international GHG emissions treaty and forecasts of these have already been included in the baseline against which potential global reduction targets were determined. As a result, non-additional market-based activities cannot be counted as offset projects without increasing emissions above the global target. Hence, all projects that apply for credit must demonstrate that they are additional to what would otherwise have occurred. The second requirement stems from the need to ensure accuracy in estimating the emission baseline in order to promote credibility. Two issues in particular have an impact on the level of error. These include (1) the treatment of additionality as a criterion for project certification and (2) the consideration of temporal issues in the development and quantification of baselines. As a third requirement, baseline approaches should provide a transparent (i.e., standardized, clearly defined, and easily replicable) methodology for estimating baselines to facilitate increased participation and ensure the credibility

of the emission credits. Finally, an effective baseline methodology should minimize transaction costs to encourage the inclusion of a maximum number of market-based projects.

Considering these four criteria, there are trade-offs between the objectives of ensuring accuracy, transparency, and low transaction costs. To increase transparency and reduce transaction costs a certain level of standardization in the application of the baseline approach is required. However, as baselines become more standardized, the level of error in estimating credits increases. This chapter provides an overview of three baseline methodologies, the project-specific approach, the benchmark approach, and the modified technology matrix approach, and discusses the benefits and disadvantages of each approach with respect to how they respond to each of the four requirements outlined above.

The project-specific approach to baseline development is based on an extensive estimate of total GHG emissions with and without the market-based project. Following this approach, additionality is assessed through an evaluation of a project's economic feasibility and an examination of possible non-financial barriers to project implementation and the baseline is quantified using a historic and dynamic analysis. Projects applying the project-specific approach will be dealt with on a case-by-case basis by a certification board and the entities involved in the project. National programs implementing the Activities Implemented Jointly (AIJ) Pilot Phase have relied solely on the project-specific approach for project evaluation. This approach has received extensive criticism for its high transaction costs and the level of complexity involved in baseline development. However, as the project-specific approach makes every effort at determining what would have happened in the absence of market mechanism incentives, it is potentially the most accurate method for setting baselines.

The second methodology is the benchmark approach. This approach relies on an average, median, or other metric derived from a defined aggregate or category (such as a specific region, sector, or technology) to determine the amount of emissions reduced by a given project. Based on the performance of this aggregate, a benchmark is then developed, which projects must improve upon in order to generate valid emission reductions. Thus, the benchmark is based on a comparison of emission rates alone. Benchmarks may be aggregated at a national, sector, sub-sector, or global/regional level, and can be quantified by using a historical, projected, or normative method. Eliminating the use of a site-specific, case-by-case estimation of emissions with and without the project increases transparency and reduces transaction costs. However, the benchmarking approach does not address the issue of additionality separately from the construction of the emission baseline, raising doubts about the environmental integrity of the credits produced.

As an alternative approach to developing standardized emission baselines, we developed the modified technology matrix approach. The matrix consists of a selected country-specific list of greenhouse gas abating technologies that correspond with the sustainable development goals of the host country. Stipulated emission baselines are then determined for each technology on the list. As the sustainable development objectives of individual countries differ depending on the resources and general development objectives of the nation, it will be the responsibility of national host governments to determine which technologies should be considered for inclusion in the matrix. Sustainable development criteria are likely to include such factors as social and economic impacts, quality of

technology transferred, environmental benefits, emissions reduction efficiency, and project feasibility.

However, for a technology to be included on the list, it must also be subjected to an additionality test. This test is based on an examination of the commercial viability and market penetration of the technology and will ensure that non-additional technologies are not included in the list of qualifying technologies. Once it has been proven that a technology is in fact additional, a baseline will be developed for that specific technology based on the emissions performance of a select group of comparable technologies within that country. Individual projects applying for emissions credit will then simply demonstrate that the proposed project technology is already listed on the technology matrix, and then use the stipulated baseline from the matrix to calculate the emission reductions of the project. Both the additionality status of the technology and the baseline against which emission credits are compared will be updated regularly. Thus, by introducing a level of standardization to the baseline development process while at the same time subjecting technologies to a rigorous additionality test, the modified technology matrix represents the middle-ground between the objectives of ensuring accuracy and promoting participation in the market mechanisms.

Chapter 3. Recommended Generic Procedure for Establishing Emission Baselines

Two primary conclusions are drawn based on the authors' assessment of the three proposed procedures. First, although it should substantially reduce transaction costs, the benchmarking approach has a significant disadvantage: at best, it addresses the issue of additionality in an indirect and unreliable manner. Second, the choice between the project-specific approach and the modified technology matrix approach is best made on a project-by-project basis, because each approach offers significant advantages over the other depending on the specific circumstances.

The benchmarking approach offers project sponsors significant opportunities for gaining emission reduction credits without reducing emissions. In fact, the benchmark approach strongly favors investment in non-additional projects at the expense of additional projects, for two reasons. First, a numeric benchmark will, at best, prove a crude screen for additionality, which could ultimately lead to the mis-classification of many non-additional projects as additional (and vice versa). Second, because non-additional projects will, by definition, tend to be more economically viable than additional projects, project developers will preferentially invest in the mis-classified non-additional projects at the expense of truly additional projects.

Unlike the benchmark approach, both the project-specific and modified technology matrix approaches are designed to directly address the issue of additionality. In the case of the project-specific approach, the viability of each individual project, without market mechanism incentives, is assessed using such means as economic feasibility analysis and project barrier analysis, while the modified technology matrix approach involves a direct assessment of the commercial viability of individual technologies. Furthermore, both the project-specific approach and the modified technology matrix approach provide reasonably reliable means for estimating the baseline.

However, neither the project-specific approach nor the modified technology matrix approach is a panacea. Exclusive reliance upon one or the other approach may result in significant lost opportunities, as a result of either the expense of implementing the project-specific approach or the automatic disqualification of all projects involving conventional technologies under the modified technology matrix approach. However, a flexible protocol incorporating both approaches will enable the application of the optimal approach in each specific situation.

To ensure appropriate selection between the project-specific and modified technology matrix approaches under a flexible protocol concept, several guidelines need to be developed. The technology matrix should be the default procedure for analyzing all projects involving the installation of new generating capacity utilizing one of the qualifying technologies. There are three exceptions to this rule. First, the approach cannot be used in host countries for which a list of qualifying technologies, or an appropriate set of benchmarks, has not been developed. Second, project developers should be allowed to utilize the project-specific approach to develop their own baseline, if they so desire, and if they can demonstrate, to the satisfaction of a review board, that the baseline thus estimated is more accurate, for their particular project, than the sectoral benchmark. Finally, if the new capacity is being developed primarily to replace existing capacity or generation, rather than to meet new demand, *and* if it is possible to readily identify the existing capacity or generation being replaced, then the emissions from this existing capacity/generation should be used as the baseline rather than a sector benchmark.

For all projects involving non-qualifying technologies or conventional technologies, the project-specific approach must be utilized. However, projects involving the retrofitting of advanced, qualifying technologies may utilize the technology matrix to establish additionality while utilizing the project-specific approach to establish the baseline.

In the following three sections, the three case studies are summarized. Then, our critique of the three project analysis is presented. Finally, the report's main conclusions and recommendations are presented.

Chapter 4. Emissions Baseline Development for the Indian Power Plant Efficiency Improvement Project

The Indian Power Plant Efficiency Improvement project is based on an ongoing project – the Greenhouse Gas Pollution Prevention Project (GEP). The efficiency improvement activities are being conducted under the Efficient Coal Conversion (ECC) component of the GEP project. The primary sponsor of the GEP project is the U.S. Agency for International Development (USAID); in addition, the project team includes the U.S. Department of Energy's National Energy Technology Center (NETL), the Electric Power Research Institute (EPRI), the Tennessee Valley Authority (TVA), and India's National Thermal Power Corporation (NTPC). The goal of the project is to reduce carbon dioxide emissions by improving the efficiency of existing coal-fired power plants.

The power plant energy efficiency improvement project involves systematic performance monitoring and diagnostic testing of the boilers, turbines, condensers, and auxiliary equipment at NTPC's coal-fired power plants. Through industry-standard tests specific plant components are identified that are operating at less than design or optimal efficiency. Corrective actions include capital improvements to worn equipment, procedural changes in plant operations, training of NTPC personnel, and dissemination of knowledge and information gained through the project.

Our hypothetical project is in effect a replication of the activities being performed under the GEP project. Specifically, we assume that these activities are extended to the coal-fired power plants owned by India's various State Electricity Boards. The hypothetical project is referred to in this report as the Indian Power Plant Efficiency Improvement Project, to distinguish it from the real-world GEP project.

The project-specific approach is selected as the baseline development approach for the hypothetical project. The project-specific approach is preferable for two reasons. First, the project involves conventional technology and improvements to an existing power plant. Second, the additionality of the project cannot be demonstrated based solely on a consideration of technology.

Under the project-specific approach, a project's additionality is demonstrated either through an economic feasibility analysis or by providing evidence of non-economic barriers (financial barriers or knowledge barriers) that would prevent the project from being undertaken without the market mechanism incentives. For this project, additionality cannot be demonstrated through an economic feasibility analysis. The project is designed to yield significant efficiency improvements at relatively low costs, and is designed to be replicable throughout the Indian power sector. At first, one may think that the project would not qualify as additional based on the grounds that it would be economic without market mechanism assistance. Nevertheless, certain barriers do exist that would prevent the project from being fully replicated throughout India until it receives the favorable development assistance from the U.S. sponsors.

To identify these barriers and demonstrate additionality, a non-economic barrier analysis is performed. The first step in this analysis is to determine if a financial barrier to project implementation exists. India's State Electricity Boards (SEBs) are in very poor financial health, leading to the tentative conclusion that the SEBs will not fund similar improvements without some form of development assistance.

Other barriers to project implementation may also exist. It is argued that SEB personnel lack the technical knowledge and training necessary to implement the project on their own, demonstrating the existence of a knowledge barrier. Based on this argument, we again conclude that the project qualifies as additional.

After having established that the Indian power plant efficiency improvement project satisfies the additionality criterion, the project's emission baseline is estimated. Under the project-specific

approach, the baseline represents a projection of what emissions would have been “but for the project.” To answer the question of what would have happened had the Indian efficiency project not been undertaken, the authors follow a standardized step-by-step procedure to identify the most likely alternative emissions scenario to the project. Thus, it is determined that the most likely alternative to the efficiency improvements throughout India would be that utility customers would have relied more heavily on self-generation. In India, electric generating capacity is insufficient to meet demand and many utility customers use diesel generators to backup the grid. Because the efficiency improvements result in an increase in the total power available to end users, as well as a reduction in the fuel consumed for generation, we conclude that in the absence of the project, diesel generators at the point of electricity consumption might be utilized more heavily. Furthermore, we conclude that the project reduces emissions at the affected power plants as well as at the backup generators. A flexible set of algorithms has been specified to quantify the emission reductions at each or both of these two sources.

Chapter 5. Emissions Baseline Development for an Integrated Gasification Combined Cycle (IGCC) Power Project in China

The Integrated Gasification Combined Cycle (IGCC) project in the People’s Republic of China (PRC) has been selected because of the interest of the Chinese government in building an IGCC demonstration project and developing domestic capability to produce IGCC technology. The construction of a commercial-scale demonstration IGCC plant by 2000 has been listed as a priority under the PRC’s Agenda 21 program. Our hypothetical IGCC market-based project in China will consist of two units, adding 300 and 400 MW of new generation capacity to the grid. The IGCC power plant could be placed in one of the provinces facing severe power shortages, such as Shandong, Gansu, Henan, Wueinghai or Sichuan. The project would rely on imported technology obtained through a combination of direct purchase and technology transfer. The targeted unit efficiency will be 43 percent or higher. If market mechanism incentive become available, project financing would most likely be obtained through a combination of Chinese support and funding from international lending institutions and private investors interested in obtaining emissions credits in exchange for their assistance.

This IGCC project is analyzed using the modified technology matrix approach for two reasons: 1) it involves the construction of new generating capacity and 2) IGCC is an emerging technology that is not yet commercial in China. In Chapter 5, we focus on *qualifying* IGCC technology, and *developing* the stipulated benchmark for inclusion in the technology matrix, rather than *applying* the matrix to the particular project. In this way, we assess IGCC technology in general without reference to the specific project under consideration.

We begin with an assessment of the additionality of IGCC technology. The additionality of IGCC technology may be demonstrated by evaluating the *economic feasibility* and the *market penetration* of the technology. If the technology is found to be unable to compete economically with existing technologies on the market and has failed to reach even a minimal level of market penetration, the technology will qualify as additional. This evaluation should be based on the specific circumstances

of the host country and the technology matrix should be developed on a country-by-country basis. Ideally, the technology should qualify only if it meets both the economic feasibility and the market penetration tests. In China, IGCC technology clearly is not commercial, and unless favorable financing is provided through market mechanisms, it will continue to be viewed as too expensive. Moreover, the market penetration rate of the technology in China is zero, and the country has only recently developed the capacity to construct IGCC units domestically. Hence IGCC technology is clearly additional and should be included in China's technology matrix.

Having considered the issue of additionality, the next step is to estimate the emissions baseline. Given a fully developed technology matrix, this is a simple and straightforward process. A stipulated benchmark will be provided for all participating countries and pre-qualifying technologies; the project developers need only identify the appropriate benchmark for their project, and use it as the basis for their emissions baseline. Because a matrix has not yet been established, we focus on the estimation of a benchmark for IGCC projects in China. We begin by addressing the question: what is the most likely alternative to the particular technology under consideration? China needs every megawatt of capacity possible to meet new demand needs arising from the expected expansion of the economy of the next 20 years. It seems prudent to conclude that, in general, new IGCC power plants in China will serve to meet new or currently unmet demand. In light of this conclusion, the next question becomes how would this demand have been met in the absence of this IGCC project? After analyzing several alternatives, we conclude that in general, the counterfactual (the existing project to be replaced) for an IGCC project in China will be a coal-fired power plant utilizing conventional technology, of roughly comparable size to the IGCC plant and located on the same site.

We consider the possibility of using a function, rather than a constant, as the benchmark to capture variations in the counterfactual power plant's heat rate (and hence, its emissions) with factors such as coal quality and utilization. However, owing to limitations in gathering detailed data within this study, it is not clear that the utilization of a functional approach to benchmark determination would represent a significant improvement over the use of a constant. Therefore, the use of a constant rather than a variable benchmark is recommended. Furthermore, a benchmark value based on heat rate (Btus per kilowatt-hour), rather than an emissions rate (pounds of carbon dioxide per kilowatt-hour), is recommended because it will enable us to consider variations in the coal's emission factor across different coal ranks. In other words, separate emission factors (in pounds carbon dioxide per mmBtu) for each rank of coal will be developed and applied to a single benchmark heat rate to determine baseline emissions. The use of rank-specific emission factors is warranted because there are small, but statistically-significant, differences in emission factors for different coal ranks.

Despite our rejection of the functional approach to benchmark development, we recognize that the benchmark should not remain static with respect to time. In other words, the benchmark constant should be updated on a periodic basis to reflect changes or improvements in the operating efficiencies of new coal-fired power plants. It is believed that re-estimation once every five years will be sufficient to keep the benchmark up to date.

Chapter 6. Fuel Cells in Argentina

The proposed Argentinian Fuel Cell project, like the Chinese IGCC project, is hypothetical in nature. At present, there are no operating fuel cell generators in Argentina, nor are there any demonstration projects. However, the Argentinian government has a strong interest in fuel cell technology, primarily for off-grid applications to meet growing rural electricity demand. Much of Argentina's electricity demand growth comes from rural areas that rely heavily on diesel generators to meet their power needs. Our hypothetical project will involve the use of a solid oxide fuel cell (SOFC) as an off-grid generator for a rural village.

As was the case for the China IGCC project, the modified technology matrix approach to emission baseline development is utilized. Clearly, this is a new capacity project utilizing an advanced qualifying technology, which leads us to the modified technology matrix approach. Once again, we focus on the *development* of the technology matrix for fuel cell technology in Argentina rather than its *application* to this particular project. We develop the technology matrix for SOFC technology in Argentina, by (1) demonstrating the additionality of this technology and (2) developing an appropriate emissions benchmark for the technology.

The additionality of SOFC technology in Argentina can be readily demonstrated based on both the economic feasibility and the market penetration of SOFCs. At present, although the application of SOFC technology is growing in the distributed generation market, it is still not considered a proven or mature technology. In fact, the operational performance of SOFC systems is still being tested, although results achieved so far promise acceptable component life characteristics. Moreover, the cost of SOFC technology has still not reached a level where it is competitive on the electricity market.

With regard to market penetration, to date, no fuel cells of any type have been installed in Argentina. Nor have SOFCs achieved significant market penetration levels on a worldwide basis. The technology has been installed at numerous test sites and research facilities. However, these activities have come about mainly through public research support and other incentives. In conclusion, SOFCs have not yet penetrated the Argentine or world markets on a significant scale, providing another indicator that the technology is additional and qualifies for inclusion in the technology matrix.

Having addressed the additionality issue, we now turn to the development of the emissions benchmark for SOFC technology in Argentina. We begin with the following basic question: what is the most likely alternative to the qualifying technology? Recalling Argentina's electricity demand growth in rural areas, the country's interest in utilizing fuel cells to meet this demand growth, and the country's heavy reliance on diesel generators to meet current rural electricity demand, we conclude that the most typical alternative to stationary fuel cell projects is likely to be diesel generators. Therefore, we base the emissions benchmark on the emissions characteristics of diesel generators in Argentina.

In the case of SOFCs in Argentina, we propose that the average emissions rate for new diesel

generators (in pounds CO₂ per kilowatt-hour) be used as the benchmark. We have decided on new diesel units for two reasons: 1) any fuel cell project in Argentina will be a new capacity project and 2) Argentina's interest in fuel cells is primarily linked to meeting new demand growth in rural areas, leading to the conclusion that an SOFC project will displace new diesel generators rather than existing generators. We propose that units installed within the past five years be used as the basis for the benchmark. By multiplying the average heat rate of new diesel generators with the diesel fuel emissions factor, the appropriate benchmark emissions rate can be readily derived. The emissions baseline for any particular SOFC project, in a given year, could then be computed by multiplying the benchmark emissions rate by the amount of electricity (in kWh) generated by the fuel cell(s).

Whenever possible, the benchmark should be based on actual heat rate data for operating diesel generators. However, in some instances, such as smaller diesel generators owned by the end users, it may well prove difficult if not impossible to obtain the required heat rate data from the generator owners. In these cases, it may be necessary to use heat rate estimates provided by manufacturers for specific models, in combination with market share data for the different models.

Like the China IGCC project, a constant, as opposed to a functional, benchmark will be utilized with respect to all variables except one –time. To ensure that the benchmarks remain a realistic indicator of current conditions, it will be necessary to update them on a regular basis. A new set of benchmarks, to be applied to new projects only, will be derived every five years. At the same time, the benchmarks to be applied to *ongoing* projects would also be updated every five years. The use of time sensitive benchmarks will capture any changes in the counterfactual emissions rates, thereby reducing the potential for biases in the emission reduction estimates.

Chapter 7. Critique of the Project Analysis

This section summarizes our critique of the three project analysis with a view towards identifying their strengths and weaknesses, and drawing out the lessons that might be learned from this case study. We address a number of specific issues: 1) fundamental project analysis difficulties arising from the characteristics of developing economies, 2) weaknesses in the analysis of the Indian Power Plant Efficiency Improvement project, and 3) the potential for errors, both random and systematic, in the estimation of project baselines.

A number of factors unique to energy markets in the developing world hold implications for baseline development. The most important characteristics are the persistent, chronic supply-demand imbalances. There are two types of imbalances particularly important to the analysis of market-based projects in the power sector: electricity imbalances and fuel imbalances. Electricity imbalances proved to be a major complicating factor in the case of the India project. Because of these imbalances, efficiency improvements may result in increased generation as well as reduced fuel consumption. The potential additional generation is, in turn, expected to displace small end-use diesel generators located at numerous industrial and commercial establishments throughout India. Obtaining reliable emissions-related data on these generators will be a very difficult undertaking.

As for fuel supply-demand imbalances, the basic concern is that if the fuel demands of power plants are going unmet, then market-based projects designed to reduce power plant fuel demand may have *no impact* on fuel consumption or emissions. Rather, such projects may simply reduce the size of the supply-demand gap. In countries facing fuel supply shortages, consumption is determined not by demand but by supply constraints; projects that reduce demand without addressing the supply constraints will have no impact on emissions. For example, if a solar-power irrigation pump is installed on a farm in India, and the farm disconnects from the grid, the electricity is simply used elsewhere by another consumer.

Our critique of the India project uncovered significant weaknesses in the arguments used to support the project's additionality. We use the non-economic barrier approach to establish that the project is additional; however, both the financial barrier argument and the knowledge barrier argument are weak in certain key respects. The basic weakness in the financial barrier argument is that it is not specific to the project at hand. We conclude that the SEBs' weak financial situations would prevent them from taking on the project themselves, but, by this same logic, we would have to conclude that the SEBs are precluded from undertaking all projects. Yet clearly the SEBs do take on some projects. The basic weakness in the knowledge barrier argument is that it relies too heavily on generalities, anecdotal information, and a limited amount of data that might not be available to project developers in actual circumstances.

Other potential error sources were identified through our analysis of the Indian project, and the Chinese and Argentine projects. These include uncertainties surrounding the establishment of the qualitative counterfactual; potential biases inherent in certain critical data; and potential biases arising from additionality classification errors.

To deal with these potential errors, we consider two possible approaches: (1) reducing biases through the development and application of rigorous baseline development procedures and (2) accommodating biases within the framework of future international agreements. The first option may be the best available option for reducing additionality classification errors in a cost-effective manner (i.e., the modified technology matrix with a stringent technology qualification/additionality criteria), but the second option may prove preferable for dealing with the biases arising during the baseline estimation process. This latter option might, for example, involve the addition of constant or variable adjustment factors to the emission targets established under future international accords, to account for systematic errors in market mechanism emission reduction estimates.

Chapter 8. Summary and Conclusions

This report presents a detailed analysis of two alternative approaches to estimating project emission baselines under a market-based mechanism environment: the project-specific approach and the modified technology matrix approach. The project-specific approach was applied to a heat rate improvement project at coal-fired power plants in India, while the modified technology matrix was applied to an IGCC project in China and a fuel cell project in Argentina. The main conclusions of this

report can be summarized as follows:

- *Emission baseline estimation is a very difficult and highly uncertain process.* This, in the authors' view, is the most important conclusion to be drawn from the three project analysis. These analysis illustrate that, regardless of the approach, there are potential sources of error. Furthermore, some of these error sources are likely to cause biases in emission reduction estimates at the global level. Of particular importance, the existence of supply-demand imbalances in developing countries is a major complicating factor in project analysis, and a particularly troublesome source of potential errors.
- *Additionality classification errors are of fundamentally greater concern than baseline estimation errors.* This conclusion follows from three main considerations. First, because of asymmetry in the outcomes following upon classification errors, such errors, even if randomly distributed, will lead to the systematic overestimation of market based project emission reductions. Second, because they are more viable than additional projects, the misclassification of non-additional projects as additional will result in preferential investment in these projects at the expense of additional projects. And third, additionality classification errors will always lead to large errors in emission reduction estimates, equal to 100 percent of the estimated project reductions. Rigorous additionality testing may thus provide the best means of guarding against large systematic biases in emission reduction estimates at the global level.
- *To the extent that cost-effective error reduction techniques can be applied, they can be utilized to reduce the potential for systematic errors in the estimation of emission baselines.* However, because it will prove unduly expensive to attempt to eliminate all such errors, and because, in any event, some systematic errors would almost certainly remain even given the most diligent attempts at error elimination, another more cost-effective option may be to explicitly accommodate the likelihood of market mechanism errors in future international agreements. This accommodation may take the form of constant or variable adjustment factors, to be applied to the emission reduction targets specified in future agreements.
- *Since the benchmarking approach to baseline estimation has little direct relevance to the issue of additionality, its application would probably lead to the mis-classification of large numbers of non-additional projects as additional (and vice versa).* Because non-additional projects, by definition, tend to be more viable than additional projects, project developers will exploit the benchmarking approach (knowingly or unknowingly) by preferentially investing in the misclassified non-additional projects, at the expense of truly additional projects. As a result, the number of emission reduction credits awarded will exceed the reductions actually achieved, potentially undermining emission reduction goals.
- *By combining the technology-based test for additionality with the benchmarking approach, the modified technology matrix represents a potential alternative to the benchmarking*

approach. The modified technology matrix is applicable to all projects utilizing advanced, non-commercial technologies.

- *Because the modified technology matrix is limited in its scope of application to advanced technologies, it should not be used as an exclusive baseline methodology but should be used in combination with another approach.* For example, the project-specific approach could be applied to projects utilizing conventional commercial technologies not covered by the technology matrix.